521282S Biosignal processing II (Lab exercises, spring 2019)

Lab III - Topographic analysis of EEG

Objective

The aim of this exercise is to learn to analyze the topographical changes in EEG. We will be examining such changes at different anesthetic levels with the EEGLAB toolbox. A sample of EEG data recorded from 13 channels during induction of anesthesia with propofol is used. Similar to Lab II, the patient is awake in the beginning of the recording. A fixed propofol infusion rate was used so the anesthesia deepens continuously. Unconsciousness is reached at about 3 minutes and in the end of the recording very deep anesthesia is reached.

In the exercise, EEGLAB is first downloaded and installed. Then, total signal power of each of the 13 channels is computed based on the spectrogram of the signal. The total power is used to plot a topographic map at different depths of anesthesia. Based on these maps, topographical changes in EEG at different anesthetic levels are analyzed. Finally, the relative alpha and delta powers are compared based on topographic maps.

In order to pass the exercise, all correctly executed task results marked with an arrow bullet (➢) must be personally presented to a course assistant during the scheduled laboratory exercise.

Implementation

The data and instructions needed for this exercise can be found in the Biosignal Processing II course webpage (see the Noppa system link in the footer of this document).

Download the following two files

- '521282S_data_3.mat' containing
  - the 13 channels of EEG data in a matrix 'signal'
  - the electrode location identifiers in a vector 'channelNames'
  - time vector 't' (time in minutes)
  - sampling frequency 'Fs'
- 'channelLocations.locs' containing locations of electrodes.

Recall the usage of 'spectrogram' which is needed in this exercise.

Store your solutions in **a single script code m-file** that provides the required task results.

1. Setting up EEGLAB

Open http://sccn.ucsd.edu/eeglab/ in a web browser. In the section labeled "EEGLAB Manu", there is a link to Download. Following the link, you are given a dialog to enter your name and an email address and to accept the GNU license terms. After you have filled the required fields, press "Submit".

In the following page, press the download link for the most current version of EEGLAB.

Extract eeglab.zip into a folder. In Matlab, add the code folder to the path by selecting 'Set Path' and from the Set Path window 'Add with Subfolders'.

Confirm that EEGLAB is properly installed by executing 'help topoplot' from the Matlab command prompt and familiarize yourself to the usage of 'topoplot'.

- Plot the electrode locations given in 'channelLocations.locs' using 'topoplot'. (NOTE: You don't have to open 'channelLocations.locs', it can be given directly as an argument to 'topoplot'. For usage examples, see the "Usage" section from the command 'help topoplot'.)

2. Signal power and topographic analysis

Load the data file '521282S_data_3.mat'.

Calculate the spectrograms of the 13 signals using the function 'spectrogram'. For input, use the same arguments as in Lab II: the raw EEG data, 30s window, 29s overlap, and sampling frequency 'Fs'. In addition, define the frequencies at which the spectrogram is computed (input parameter 'F' given before the sampling frequency 'Fs') by vector [0.1:0.1:32] to get the estimates between frequencies 0.1Hz and 32Hz with 0.1Hz resolution. Collect all of the four output parameters ('S', 'F', 'T', and 'P') of the function for each of the 13 channels. (TIP: You can reuse code from Lab II.)

Calculate the total power in each of the 13 channels.

- Plot the $\log_{10}$ of the total power at the 13 channels at the start of the recording, at 2min, at 5min and at 7min using the 'topoplot' function. Use the 'subplot' command to plot each of these maps into a single window. Use also the 'maplimits' argument of 'topoplot' to scale map colors to data range.

Sum the channels from the four frontal electrodes Fpz, F7, Fz and F8 into a single combined signal. Do the same for the four rear electrodes P3, Pz, P4 and Oz.

- Plot these two signals into single figure. What can be seen from the figure as the anesthesia deepens?

The material used in this exercise can be found in the course web page at
https://noppa.oulu.fi/noppa/kurssi/521282s/harjoitukset

3. Relative powers and topographic analysis

Calculate the relative power in the alpha and delta bands for each of the 13 channels by summing the power spectral density values ('P') in the corresponding frequencies at each time point and dividing the sum by the power in the entire frequency range (0.1-32Hz) at the same time point. You can use output variable 'F' to confirm the samples correspond to the right frequency band. (TIP: Again, you can reuse code from Lab II.)

- Plot the topographic map of relative alpha and delta power at the start, at 2min, at 5min and at 7min using the 'topoplot' function. To compare the alpha and delta powers, plot the topographic maps side by side using 'subplot'. For comparison, scale the map colors to [0,1] using the 'maplimits' argument.